to such a point for the purpose of guarding against undue expectations and of disclaiming excessive pretensions. The work that has been executed in India is of such a character, as attested by an enormous accumulation of results treated with absolute rigour, that, as respects some branches of it, I do not shrink from saying that improvement is scarcely possible. In respect to horizontal angles, the most important of all its branches, an elaborate investigation by Colonel Walker, R.E., F.R.S., the present head of the Survey, shows that the probable error of such angles, deduced impartially from a vast mass of materials, lies between $\pm 0''{\cdot}28$ and $\pm 0''{\cdot}20$, according as the circumstances are more or less favourable *. I believe that residual errors of that small amount contain hardly any instrumental or observational element, but that they are chiefly due to atmospheric disturbances, which no instrumental perfection can control.

As to vertical angles, the test of direct levelling compared with trigonometrical levelling, applied to a distance of 2700 miles, shows a difference between the results of these two independent methods averaging 7·3 inches per 100 miles, or $\frac{7}{100}$ of an inch per mile. There seems little room for instrumental improvement here.

In respect to astronomically determined azimuths, I hope the present instrument will give improved results, on account of the superior steadiness of level which I think it possesses.

For the determination of astronomical latitudes it has more powerful and more complete vertical appliances than any former theodolite, and it should therefore give better results.

Finally, I believe it will be found to be more permanent in its adjustments, and more convenient both to adjust and to use, than any of its predecessors. To these points, as those which makers, not being observers, are peculiarly prone to overlook or mismanage, I have given the most earnest attention, knowing how indispensable it is that a man engaged in the most difficult and refined of all observations should be spared every anxiety and inconvenience which it is in the power of mechanical contrivance to prevent. If I have in some measure only attained this apparently humble object, I shall feel that the labour of years and the anxious ponderings of many a sleepless night have not been in vain.

II. "On some Elementary Principles in Animal Mechanics.—No. V. On the most perfect form of a Plane Quadrilateral Muscle connecting two Bones." By the Rev. Samuel Haughton, F.R.S., M.D. Dubl., D.C.L. Oxon., Fellow of Trinity College, Dublin. Received April 3, 1872.

Let us suppose two bones, A B and A′ B′, lying in the same plane, joined by muscular fibres, and any two planes drawn through these bones inter-

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* Account of the operations of the Great Trigonometrical Survey of India, by Col. J. T. Walker, R.E., F.R.S., &c., Superintendent of the Survey, vol. i. pp. 83, 84.

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secting in a line P Q. If we suppose one bone A B to be fixed and the other bone A′ B′ to be movable, and that the contraction of the muscle compels the bone A′ B′ to revolve round P Q as an axis of rotation, it is required to find the conditions necessary in order that the work done by the contraction of the muscle shall be a maximum. I shall in this note discuss only the case in which the bones A B, A′ B′ lie in the same plane. In this case I have succeeded in demonstrating the following propositions in the case of maximum work:—

1. The axis of rotation P Q must be formed by the intersection of rectangular planes passing through A B and A′ B′.

2. The quadrilateral muscle A B A′ B′ must be inscribable in a circle.

If it be true (as I believe it is) that the muscles, bones, and joints of all vertebrate animals are so related to each other as to produce in all cases the maximum amount of work possible with a given weight of muscle, then the second proposition affords us a severe test of the truth or falsehood of my postulate. If the muscle be circumscribable by a circle, it follows, from Ptolemy's theorem, that its sides and diagonals must fulfil the following condition:—

$$ab + cd = ef,$$

where a, b are one pair of opposite sides and c, d the other pair, and e, f are the diagonals of the quadrilateral.

The *pectineus* muscle of many animals forms a plane quadrilateral when in its position of maximum extension of fibres, and therefore furnishes us with a favourable test. In the freshly dissected animal it is easy to measure with accuracy the lengths of the six lines in question, and so test the truth of the postulate.

I have thus obtained the following results:—

1. *Adult Male Lion.* Pectineus Muscle.

		in.
a.	Length of pubic origin	1·70
b.	,, femoral insertion	2·95
c.	,, anterior fibre	4·52
d.	,, posterior fibre	7·61
e.	First diagonal	5·77
f.	Second diagonal	6·76

Hence we have

$$\begin{aligned} ab &= 1{\cdot}70 \times 2{\cdot}95 = 5{\cdot}01 \\ cd &= 4{\cdot}52 \times 7{\cdot}61 = \underline{34{\cdot}39} \\ ab + cd &\;\ldots\ldots = 39{\cdot}40 \\ ef &= 5{\cdot}77 \times 6{\cdot}76 = \underline{39{\cdot}00} \\ &\text{Difference} = 0{\cdot}40 \end{aligned}$$

This difference amounts to $\frac{1}{98\cdot5}$ part of the whole.

2. *Llama.* Pectineus Muscle.

		in.
a.	Length of pubic origin	1·91
b.	„ femoral insertion	3·50
c.	„ anterior fibre	3·05
d.	„ posterior fibre	6·91
e.	First diagonal	4·09
f.	Second diagonal	6·77

Hence we find

$$\begin{array}{rl} ab = 1{\cdot}91 \times 3{\cdot}50 = & 6{\cdot}68 \\ cd = 3{\cdot}05 \times 6{\cdot}91 = & \underline{21{\cdot}07} \\ ab + cd \;\ldots\ldots = & 27{\cdot}75 \\ ef = 4{\cdot}09 \times 6{\cdot}77 = & \underline{27{\cdot}69} \\ \text{Difference} = & 0{\cdot}06 \end{array}$$

This difference amounts to $\frac{1}{462{\cdot}5}$ part of the whole.

III. "On some Elementary Principles in Animal Mechanics.—No. VI. Theory of Skew Muscles, and investigation of the conditions necessary for Maximum Work." By the Rev. SAMUEL HAUGHTON, F.R.S., M.D. Dubl., D.C.L. Oxon., Fellow of Trinity College, Dublin. Received April 3, 1872.

Let us suppose two bones, A B and A′ B′, not lying in the same plane, connected by muscular fibres; and through these bones let us draw any two planes intersecting in a line P Q; if the bone A B be fixed and the bone A′ B′ be movable and compelled to turn round the line P Q regarded as an axis of rotation, it is required to find the conditions necessary in order that the work done by the contraction of the muscle shall be a maximum.

A muscle such as is here imagined will form a skew surface, and no two of its fibres will intersect in space. I have succeeded in demonstrating the following propositions in the case of maximum work:—

1. The axis of rotation P Q must be formed by the intersection of rectangular planes passing through A B and A′ B′.

2. A certain hyperboloid of one sheet may be drawn passing through the bones A B and A′ B′; and the axis of maximum work is a generator of this hyperboloid belonging to the group different from that to which A B and A′ B′ belong.

3. The generator which is the axis of rotation of maximum work is found by the solution of a biquadratic equation.

4. In the muscles which are found in nature, the root of the biquadratic which fixes the axis of maximum work is always nearly equal to zero.

5. If there be n fibres in the skew muscle, we can draw a certain line O O′, joining two points on A B and A′ B′ (or A B and A′ B′ produced), such that a single fibre acting in the line O O′, with n times the force of a